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Process for Developing Stakeholder-Driven Requirements and Concept of Operations

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PROCESS FOR DEVELOPING STAKEHOLDER-DRIVEN REQUIREMENTS AND CONCEPT OF OPERATIONS

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INTRODUCTION

This paper describes a process for developing the requirements and concept of operations for an engineered system that are traceable to the mission goals and stakeholder needs. The determinism provided by this up-front investment during the project life cycle sets the stage for developing a solution that is responsive and traceable to the goals and needs. An overview is provided on systems architecting and systems engineering and how they fit into the larger role of project management, and a view of a project life cycle from a combined systems architecting and engineering perspective is presented.

MOTIVATION

When developing a system to satisfy a mission need or opportunity, establishing correct and complete requirements and a concept of operations (ConOps) enables informed design decisions and improves the likelihood of long-term project success. A sufficiently rigorous approach to connecting mission goals and stakeholder expectations to the design of a new system can help a project team avoid the trap of pursuing a solution that only they see as being important and ultimately failing due to the loss of sponsorship or not meeting the needs of a key end-user, support infrastructure, or interface. Referring to Figure 1, the solution development phase of a project is connected to the mission goals and stakeholders by the system requirements and concept of operations. Any discussion or examination of a proposed solution that is not framed in the context of the requirements and concept of operations runs the risk of being disconnected from the reasons and benefactors of pursuing the project.

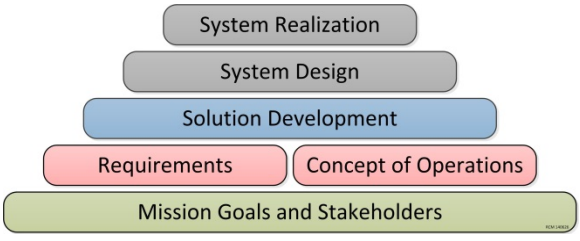

FIGURE 1. Phases in a systems architecting and engineering –centric view of a project life cycle. Mission goals and stakeholders form the foundation upon which the two pillars of requirements and concept of operations stand, providing a solid base for solution development.

SYSTEMS ARCHITECTING & ENGINEERING

Systems architecting and engineering are sometimes referred to collectively as "systems engineering". They overlap with each other but encompass two distinct areas of focus that are vital to project success [1, 2, and 3]. Systems architecting supports the stakeholders in identifying the mission goals and requirements, and exploring solution paths. It is not uncommon for an end-user or customer to be unclear about what is needed, in which case they need an advocate to help them determine those needs before momentum builds towards a particular solution. Systems engineering creates and manages the technical plan for developing and delivering a best solution, and supporting its entire life cycle. A combined systems architecting and systems engineering view of a project life cycle is shown in Figure 2. The majority of the project life cycle cost is committed when turning a conceptual design into a final design, so the up-front investment in systems architecting and systems engineering activities is important.[1] Systems architecting and engineering overlap with project control, which ensures project execution according to governing processes, and all three lie within the larger role of project management, which seeks a self-consistent balance of scope, schedule, budget, performance, and safety. The remainder of this paper focuses on working through the first two major phases in Figure 2, to establish

[1] A 1993 study of U.S. Department of Defense projects shows that 80% of a project's life cycle cost is committed by the initial 20%, and that the cost to extract defects from a system increases geometrically during the project life cycle [4].

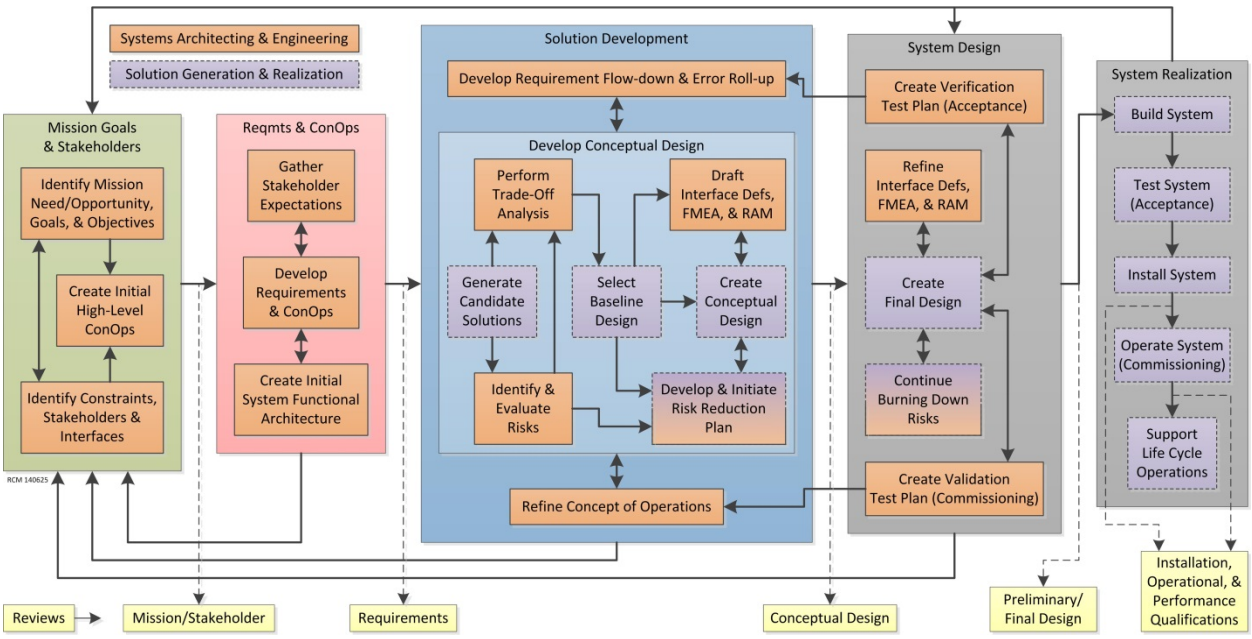

FIGURE 2. A systems architecting and engineering –centric view of a project life cycle.

requirements and a co-evolved concept of operations that are connected to the mission goals and stakeholders.

DEVELOPING REQUIREMENTS AND A CONCEPT OF OPERATIONS

The process for going from an initial mission definition to a requirements review, which includes the concept of operations, is broken down into the five phases shown in Figure 3 and is shown in schedule format in Figure 4. A graded-approach to developing requirements and a concept of operations is achieved by adjusting the depth of engagement within each phase, and the number of iterations within and between phases, to an appropriate level relative to the mission importance and project size.

Need or Opportunity Definition

At the outset of a project it is critical to establish a clear vision of the need or opportunity, goals, metrics for success, and constraints. Identifying a single mission need or opportunity helps avoid conflicting goals. Mission goals are qualitative high-level expectations for the system, and one or more objectives flow-down from each goal as quantitative targets that define how success will be determined [5]. Explicitly stating the project constraints, like schedule, budget, management or regulatory, and technology, provides clarity between the project team and stakeholders. Engaging key stakeholders during this phase provides the domain knowledge needed for accuracy and completeness, and establishes a shared understanding that can be referred to during project execution when the questions arise, “Why are we doing this, Why is it taking so long, and Why is this so hard?” A mission review assesses project-start feasibility by looking for consistency between the goals and constraints, enabling early schedule and budget adjustments and informing needed trade-offs between goals (see Table 2).

Operational Context

Knowing how a system fits into the rest of the world and how it will be used informs what it needs to be. A system context diagram, like the example shown in Figure 5, illustrates the boundary of the system, stakeholders, external interfaces, and key influences. Clearly defining the boundary between the system and its environment helps establish the scope of the project. Placing the stakeholders around the periphery of the diagram is analogous to gathering everyone around a table to discuss a shared big-picture view of the project. The system context diagram provides a basis for developing the operational scenarios for the system, from which the initial high-level concept of operations is derived. Qualitative functional, operational, and safety requirements are discovered by stepping through the concept of operations and asking, “What is needed to

FIGURE 3. Process for developing stakeholder-driven requirements and concept of operations. Iterations within each phase (vertical swim lanes) and between phases are not shown. The dotted lines connect the output of this process to the third major phase (Solution Development) in Figure 2.

perform this step?" Typically, each of the resulting requirements flows down to one or more quantitative performance requirement.

Stakeholders, External Interfaces, and Initial Requirements

As the system context diagram and operational scenarios are developed, the list of stakeholders and external interfaces evolves through a process of discovery and refinement. Engaging the stakeholders[b] that will interact with and be responsible for the deployed system informs the development of the concept of operations, its related requirements, and the validation plan. Additional high-level requirements are identified during discussions with key stakeholders, and drawn from experience with a similar mission or system context. Grouping all the requirements by type as shown in Table 1 focuses stakeholder discussions, reveals omissions, and enables re-use between projects. To ensure adequate completeness during this phase, it is helpful to maintain a (growing) list of stakeholder domains and external interfaces, and to identify the people who will represent and speak for them during discussions. By the end of this phase a clear vision can be articulated regarding the mission need or opportunity, goals, objectives, constraints, system context, and initial high-level requirements and concept of operations. Establishing a broad view of the system and who will expect what from it helps prioritize and focus the more extensive stakeholder discussions during the next phase. A stakeholder review provides an early project-readiness assessment by looking for a big-picture view and engagement of the right set of people needed to develop correct and complete requirements and a concept of operations (see Table 2).

[b] "Active" stakeholders are responsible for and interact with the deployed system. "Passive" stakeholders influence the development and success of the system but do not directly interact with it [5].

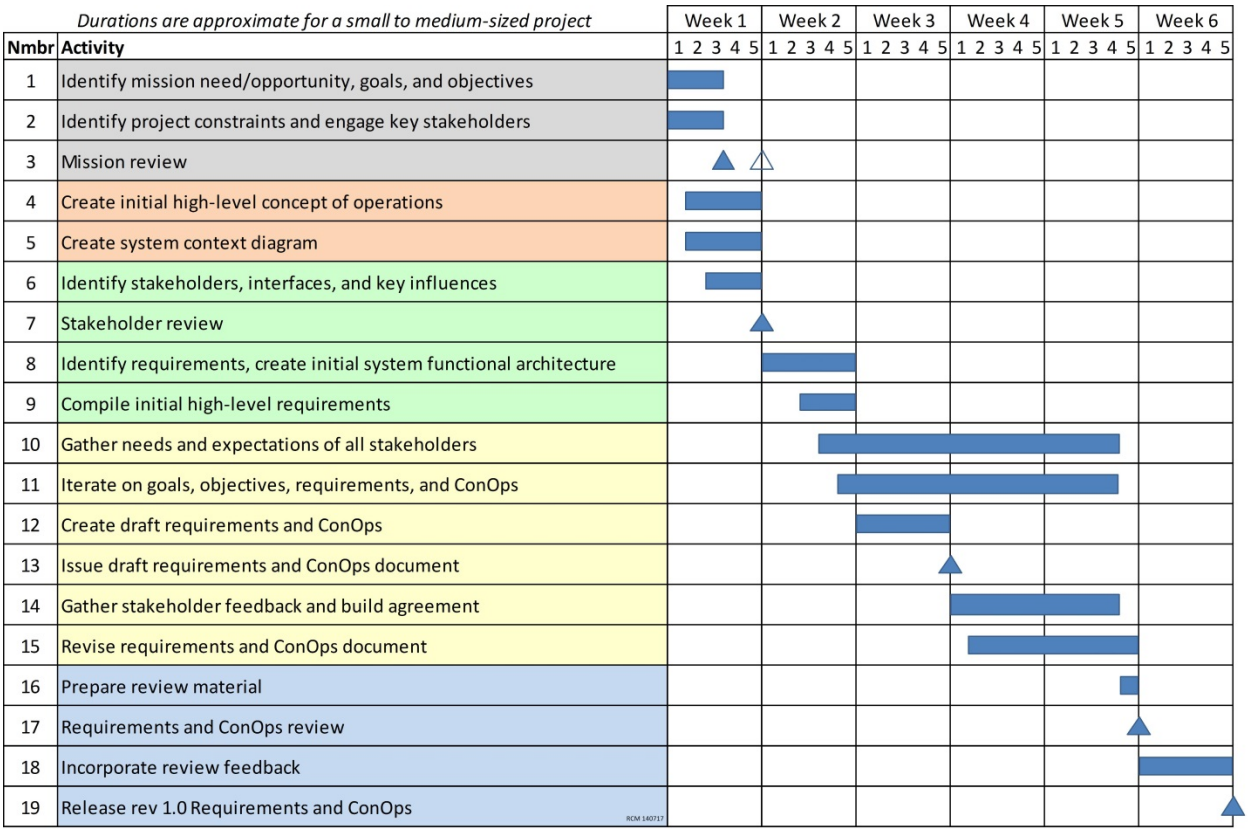

Figure 4. Schedule version of the process for developing stakeholder-driven requirements and concept of operations. Durations are approximate for a small to medium-sized project. The mission and stakeholder reviews can be combined (as indicated by the unfilled triangle).

Refining with Stakeholders

A systems architect/engineer's talents and skills for networking, listening, and being organized are fully called upon when gathering stakeholder needs, expectations, and feedback; building agreements; and sorting through, prioritizing, and translating needs and expectations into refined versions of the requirements and concept of operations. Mapping stakeholders to the high-level requirements and concept of operations developed during the previous phase identifies whose voice needs to be heard when

0.0	Mission Need or Opportunity	Problem the system is supposed to solve or opportunity it targets
1.0	Mission Goals and Objectives	High-level expectations for the system (qualitative goals), and flow-down to how success will be determined (measurable objectives)
2.0	Functional and Performance Requirements	Functions the system needs to provide (qualitative), and flow-down to how well it needs to perform them (quantitative)
3.0	Interface Requirements	Interactions with and expectations on systems and activities outside the system boundary
4.0	Operational Requirements	Operational environment, human factors, RAM, FMEA, and recovery
5.0	Safety Requirements	Personnel health and safety, environmental protection, and equipment protection
6.0	Standards, Codes, Regulations, and Procedures Requirements	Established and approved practices, materials, processes, and protocols

Table 1. Suggested categories for organizing requirements. Although mission need/opportunity, goals, and objectives are not strictly requirements, including them in the requirements document provides traceability when judging the relative importance of a requirement to the mission.

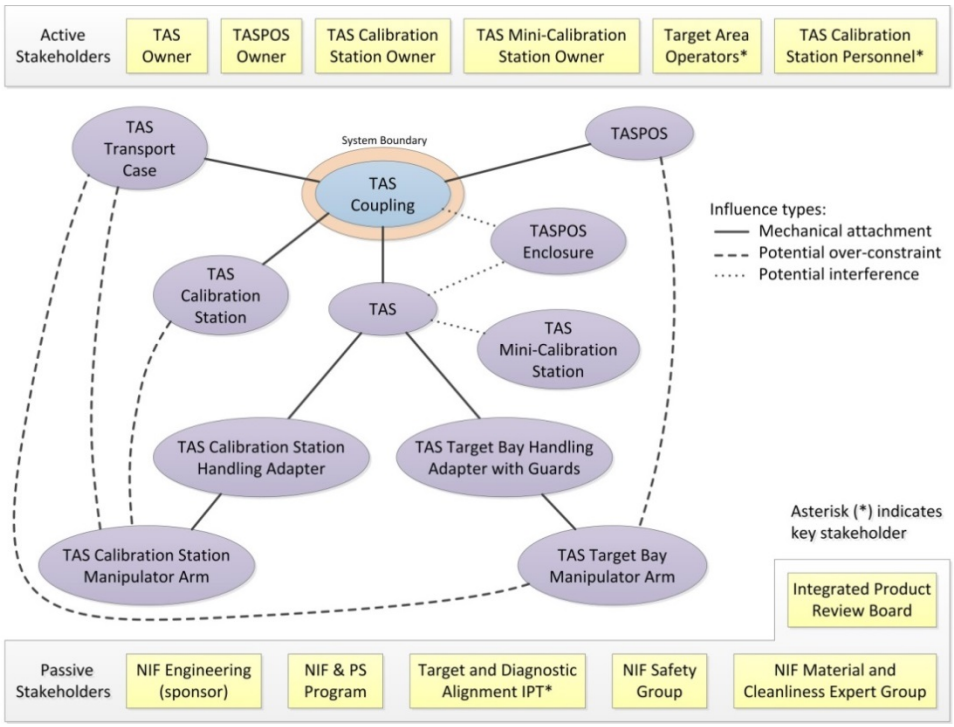

FIGURE 5. A system context diagram for the Target Alignment System (TAS) coupling for the National Ignition Facility (NIF). This simple example includes key influences between systems. The coupling provides a stable and repeatable attachment of the TAS to three other systems (one at a time).

adding to and refining them, and enables focused, efficient, and effective small-group discussions[3] during stakeholder interviews. An important job for a system architect/engineer is ensuring that the voice of every stakeholder representative is heard, captured, and considered. If an important voice is not heard until later during the project life cycle, it could be in the form of a significant shortcoming of the deployed system that would have been less costly and disruptive to deal with sooner. Success during this phase requires stakeholder involvement and feedback during interviews and reviews of draft documents. Management's support of the importance of stakeholder engagement – making it a priority – improves the likelihood of a successful project. Striving for early feedback and rapid iterations helps make efficient use of everyone's time, and can be vectored towards issuing an early draft of the requirements and concept of operations to support the solution development phase. Stakeholder feedback on draft documents identifies areas requiring refinement, additional discussion, and agreement building. Following an organized process and documenting as you go, especially keeping track of who provided input on what, identifies missing discussions, provides traceability, and helps meet an aggressive schedule.

[3] Compared to gathering everyone in a room and "battling it out" until the requirements are declared done, which risks only the dominant voices being heard and completion by attrition.

Requirements Review

Before a project commits significant resources to solution development, all five phases preceding it in Figure 3 should be considered to an appropriate degree. There is an improved likelihood of success if this is done explicitly and with traceability. A suggested review committee charter for assessing the thoroughness and appropriate graded-approach for that effort is shown in Table 2. High-level requirements are ideally solution neutral; flow-down requirements derived during the solution development phase connect them to a particular solution. Referring to Figure 2 and looking forward, a thorough solution description consists of: (1) a design driven by the requirements and concept of operations, (2) a verification plan traceable to the requirements for acceptance testing the

system, and (3) a validation plan traceable to the concept of operations for commissioning the system.

1	Are the mission need or opportunity, goals, and objectives clear, accurate, and complete?
2	Are the project constraints adequately defined and complete?
3	Are the mission goals and project constraints consistent with each other?
4	Are the system boundary, external interfaces, and key influences accurately and adequately defined?
5	Have the appropriate stakeholders been identified and included in the requirements development process?
6	Is the concept of operations correct and at an appropriate level of detail?
7	Are the requirements clear, accurate, complete, consistent, attainable, and verifiable?
8	Was an appropriate graded-approach used relative to mission importance and project size?

TABLE 2. Suggested review committee charter for a requirements review. A mission review would cover items 1-3, and a stakeholder review items 4-5 and an initial treatment of item 6 [6].

TEN TAKE-AWAY POINTS

1. The majority of the project life cycle cost is committed when turning a conceptual design into a final design, so an up-front investment in requirements and ConOps is important.
2. Engaging key stakeholders provides the domain knowledge needed for establishing an accurate big-picture view.
3. A mission review assesses project-start feasibility by looking for consistency between the goals and constraints.
4. Knowing how a system fits into the rest of the world and how it will be used informs what it needs to be.
5. A stakeholder review assesses early project-readiness by looking for a broad view of the system and engagement of the right people.
6. Organizing requirements by type focuses stakeholder discussions, reveals omissions, and enables re-use between projects.
7. Mapping stakeholders to the requirements and concept of operations identifies whose voice needs to be heard when developing and refining them, and enables focused, efficient, and effective discussions.
8. A requirements review that includes the concept of operations assesses the thoroughness and accuracy of gathering stakeholder expectations and reconciling them with the mission goals, and assesses the project team's readiness to develop a solution that is responsive to the mission.
9. Documenting as you go, especially keeping track of who provided input on what, helps identify missed discussions and establishes an explicit record that provides traceability.
10. A graded-approach is achieved by adjusting the depth of engagement and number of iterations during the process to an appropriate level relative to the mission importance and project size.

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